

CLAIMS

1. A method for fabricating thin film oxides, the method comprising:

forming a substrate;

5 treating the substrate at temperatures equal to and less than 360° C, using a high density (HD) plasma source; and,

forming an M oxide layer overlying the substrate where M is an element selected from a group including elements chemically defined as a solid and having an oxidation state in a range of +2 to +5.

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2. The method of claim 1 wherein treating the substrate at temperatures equal to and less than 360° C, using an HD plasma source includes using an inductively coupled plasma (ICP) source.

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3. The method of claim 2 wherein forming a substrate includes forming a substrate including M; and, wherein using an ICP source includes plasma oxidizing the substrate.

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4. The method of claim 3 wherein plasma oxidizing the substrate includes inductively coupling plasma:

at a temperature of 360° C;

in a range of 13.56 to 300 megahertz (MHz) with a power density up to 10 watts per square centimeter (W/cm²);

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at a pressure of up to 500 milliTorr (mTorr);

with a mixture of inert gas and oxygen in a ratio of approximately 10:1 to 200:1; and,

with a total gas flow of approximately 50 to 200
standard cubic centimeters per minute (sccm).

5. The method of claim 4 wherein inductively coupling
5 plasma includes varying a substrate bias in a range of 50 kilohertz (KHz)
to 13.56 MHz with a power density up to 3 W/cm².

6. The method of claim 4 wherein inductively coupling
plasma with a mixture of inert gas and oxygen includes mixing oxygen
10 with inert gas selected from the group including helium, argon, and
krypton.

7. The method of claim 4 wherein forming a substrate
including M includes forming a silicon layer.

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8. The method of claim 7 further comprising:
forming a transparent substrate layer; and,
forming a diffusion barrier overlying the transparent
substrate layer and underlying the silicon layer;

20 wherein forming a silicon layer includes forming transistor
channel, source, and drain regions in the silicon layer;

wherein forming an M oxide layer includes forming a gate
dielectric layer of the oxide; and,

the method further comprising:
25 forming a gate electrode overlying the gate dielectric layer.

9. The method of claim 8 wherein forming a gate dielectric layer of the oxide includes forming a dielectric layer with:

a fixed oxide charge density of less than 5×10^{11} per square centimeter (/cm²);

5 an interface trap concentration of approximately $.9 \times 10^{10}$ to 8×10^{10} per square centimeter – electron volt (/cm² eV);

a flat band voltage shift of less than 1 V;

a leakage current density lower than 10^{-7} amperes per square centimeter (A/cm²) at an applied electric field of 8 megavolts per

10 centimeter (MV/cm); and,

a breakdown field strength greater than 10 MV/cm.

10, The method of claim 7 wherein forming an M oxide layer includes forming a silicon oxide layer with a refractive index
15 between approximately 1.45 and 1.47.

11. The method of claim 3 wherein forming a substrate including M includes:

forming a base layer of a material; and,

20 depositing a thin film of element M overlying the base layer;

and,

wherein plasma oxidizing the substrate includes plasma oxidizing the thin film of M.

25 12. The method of claim 2 wherein using an ICP source includes using an HD plasma enhanced chemical vapor deposition (HD-PECVD) process to treat the substrate; and,

wherein forming an M oxide layer overlying the substrate includes depositing the M oxide layer.

13. The method of claim 12 wherein using an HD-PECVD
5 process to treat the substrate includes inductively coupling plasma:
in a range of 13.56 to 300 MHz with a power density up to 10
W/cm²;
at a pressure of up to 500 mTorr; and,
with a mixture of reactive gases and precursor compounds
10 having M in a decomposable form, the gases and precursor compounds in
a ratio selected in accordance with the valence state of M.

14. The method of claim 13 wherein inductively coupling
plasma includes varying a substrate bias in a range of 50 KHz to 13.56
15 MHz with a power density up to 3 W/cm².

15. The method of claim 13 wherein forming a substrate
includes forming a silicon layer.

- 20 16. The method of claim 15 wherein inductively coupling
plasma with a mixture of reactive gases and precursor compounds having
M in a decomposable form, the gases and precursor compounds in a ratio
selected in accordance with the valence state of M includes inductively
coupling plasma with a mixture of SiH₄, N₂O, and N₂ gases in a ratio of
25 approximately 10:100:50 to 25:100:50.

17. The method of claim 16 further comprising:

forming a transparent substrate layer; and,
forming a diffusion barrier overlying the transparent
substrate layer and underlying the silicon layer;
wherein forming a silicon layer includes forming transistor
5 channel, source, and drain regions in the silicon layer;
wherein depositing the M oxide layer includes depositing a
gate dielectric layer; and,
the method further comprising:
forming a gate electrode overlying the gate dielectric layer.

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18. The method of claim 17 wherein forming a gate
dielectric layer includes forming a dielectric layer with:
a fixed oxide charge density of less than $5 \times 10^{11}/\text{cm}^2$;
an interface trap concentration of approximately 2×10^{10} to 8
15 $\times 10^{10}/\text{cm}^2$ eV;
a flat band voltage shift of less than 1 V;
a leakage current density lower than 10^{-7} A/cm² at an applied
electric field of 8 MV/cm; and,
a breakdown field strength greater than 10 MV/cm.

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19, The method of claim 15 wherein depositing the M
oxide layer includes depositing a silicon oxide layer with a refractive index
between approximately 1.45 and 1.47.

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20. The method of claim 1 wherein forming a substrate
includes forming a substrate where M is silicon selected from the group

including amorphous silicon, microcrystalline silicon, and polycrystalline silicon.

21. The method of claim 1 wherein forming, overlying the
5 substrate, an M oxide layer includes forming an M oxide selected from the group including M binary oxides and M multi-component oxides.

22. The method of claim 1 wherein treating the substrate
at temperatures equal to and less than 360° C using an HD plasma source
10 includes using a plasma source selected from the group including electron cyclotron resonance (ECR) plasma sources and cathode-coupled plasma sources.

23. A method for fabricating thin film oxides, the method
15 comprising:
forming a substrate;
treating the substrate at temperatures equal to and less than
360° C, using a transmission/transformer coupled plasma source; and,
forming, overlying the substrate, an M oxide layer where M
20 is selected from a group including elements chemically defined as a solid and having an oxidation state in a range of +2 to +5.

24. An in-situ method for fabricating thin film oxides, the
method comprising:
25 in a film processing chamber, forming a substrate;

leaving the substrate in the film processing chamber,
treating the substrate at temperatures equal to and less than 360° C,
using a high density (HD) plasma source; and,

- in the film processing chamber, forming, overlying the
- 5 substrate, an M oxide layer where M is selected from a group including
elements chemically defined as a solid and having an oxidation state in a
range of +2 to +5.